US-PAT-NO: 6285995

DOCUMENT-IDENTIFIER: US 6285995 B1

TITLE: Image retrieval system using a query image

DATE-ISSUED: September 4, 2001

INVENTOR-INFORMATION:

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APPL-NO: 09/ 102474

DATE FILED: June 22, 1998

US-CL-CURRENT: 707/3, 707/2 , 707/6

ABSTRACT:

An image retrieval system contains a database with a large number of images. The system retrieves images from the database that are similar to a query image entered by the user. The images in the database are grouped in clusters according to a similarity criterion so that mutually similar images reside in the same cluster. Each cluster has a cluster center which is representative for the images in it. A first step of the search to similar images selects the clusters that may contain images similar with the

query image, by comparing the
query image with the cluster centers of all
clusters. A second step of the
search compares the images in the selected clusters
with the query image in
order to determine their similarity with the query
image.

10 Claims, 7 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 4

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Brief Summary Text - BSTX (5):

An **image retrieval** system and a method as
described above, are known from
the article "Tools and Techniques for Color **Image Retrieval**", John R. Smith and
Shih-Fu Chang, Proc. SPIE--Int. Soc. Opt. Eng
(USA), Vol. 2670, pp.
426-437. The **image retrieval system comprises a database with a large number
of images**. A user searching for a particular **image specifies a query image as
to how the retrieved image** or images should look
like. Then the system
compares the stored images with the query image and
ranks the stored images
according to their similarity with the query image.
The ranking results are
presented to the user who may **retrieve one or more of the images**. The
comparison of the query image with a stored image
to determine the similarity
may be based on a number of features derived from
the respective images. The

image feature or features used for comparison are called a feature vector. The article describes the usage of a color histogram as such a feature vector.
When using the RGB (Red, Green and Blue) representation of an image, a color histogram is computed by quantizing the colors within the image and counting the number of pixels of each color. To determine the similarity, a number of techniques are described to **compare** the two **color histograms** of the respective images. An example of such technique is the histogram intersection, where the similarity is the sum over all histogram bins of the minimal value of the pair of corresponding bins of the two histograms.

Detailed Description Text - DETX (41):

In the embodiments of the **image retrieval** system described above, a single color histogram is made from the whole image. Because of this, the spatial information from the image is lost and the comparison of two images reflects only global similarity. For example if a user enters a query **image with a sky at the top and sand at the bottom, the retrieved images** are expected to have a mix of blue and beige, but not necessarily a sky and sand. A desirable result for the **retrieved candidate images** would be images with blue at the top and beige at the bottom. In order to achieve this result, a further embodiment of the system according to the invention determines a **color histogram** for a number of respective regions of the query image and **compares** these determined histograms with histograms of corresponding regions

of the candidate image.
The query image may be divided into regions using prefixed boundaries, e.g. the division of the image into a number of rectangles. Furthermore, the regions may be indicated manually by the user taking into account important objects in the query image. In this way, the user forces that a histogram is made for a region comprising the object of interest. The choice of the region size is important since it governs the emphasis that is given to local information. In one extreme, the whole image is considered as a single region so that only global information is used for the comparison. In the other extreme, the region size matches the individual pixels. In one of the further embodiments of the **retrieval system according to the invention, the images** are divided into 4.times.4 rectangular regions.

US-PAT-NO: 6163622

DOCUMENT-IDENTIFIER: US 6163622 A

TITLE: Image retrieval system

DATE-ISSUED: December 19, 2000

INVENTOR-INFORMATION:

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APPL-NO: 08/ 993130

DATE FILED: December 18, 1997

US-CL-CURRENT: 382/170, 382/305 , 707/6

ABSTRACT:

In an **image retrieval system, a database with a large number of images** is searched to find one or more images meeting the specification of a user. This specification is given in the form of a query image. The system determines the similarity between the query image and a particular image from the database by **comparing the color histograms** of the two images. The histograms are treated as statistical distributions and the similarity is determined on the basis of an information theoretic measure of the distributions. In a first embodiment,

the similarity is determined using the Kullback informational divergence of the two histograms. In a second embodiment, the similarity is based on the entropy of the distribution of similarity coefficients of the two histograms is used.

9 Claims, 5 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 4

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Abstract Text - ABTX (1):

In an **image retrieval system, a database with a large number of images** is searched to find one or more images meeting the specification of a user. This specification is given in the form of a query image. The system determines the similarity between the query image and a particular image from the database by **comparing the color histograms** of the two images. The histograms are treated as statistical distributions and the similarity is determined on the basis of an information theoretic measure of the distributions. In a first embodiment, the similarity is determined using the Kullback informational divergence of the two histograms. In a second embodiment, the similarity is based on the entropy of the distribution of similarity coefficients of the two histograms is used.

Brief Summary Text - BSTX (7):

An **image retrieval** system and a method as described above, are known from the article "Tools and Techniques for Color **Image Retrieval**", John R. Smith and Shih-Fu Chang, Proc. SPIE--Int. Soc. Opt. Eng (USA), Vol. 2670, pp. 426-437. The **image retrieval** system includes a database with a large number of images. A user searching for a particular **image specifies a query image as to how the retrieved image** or images should lock like. Then the system compares the stored images with the query image and ranks the stored image according to their similarity with the query image. The ranking results are presented to the user who may **retrieve one or more of the images**. The comparison of the query image with a stored image to determine the similarity may be based on a number of features derived from the respective images. The article describes the usage of a color histogram as such a comparison feature. When using the RGB (Red, Green and Blue) representation of an image, a color histogram is computed by quantizing the colors within the image and counting the number of pixels of each color. To determine the similarity, a number of techniques are described to **compare** the two **color histograms** of the respective images. The histogram euclidean distance is a simple measure calculated by comparing identical bins in respective histograms. No cross-wise comparison is made between different bins which represent perceptually similar colors. Furthermore, techniques for determining a histogram intersection and techniques for determining a histogram quadratic distance are

described. As an alternative to the histogram techniques, a comparison technique based on color sets is described. In this technique the color of a pixel is compared with a predetermined threshold. If the color is below the threshold, the pixel does not become a member of the set and otherwise it does become a member. A disadvantage is that a large number of pixels, all below the threshold, will not contribute in the comparison in any way. Furthermore, there is no discrimination between values above the threshold. The prior art techniques for determining the similarity between the candidate image and the query image are complex to execute and/or are occasionally not adequate enough.

Brief Summary Text - BSTX (10):

An embodiment of the **image retrieval** system according to the invention uses a Kullback informational divergence. The Kullback informational divergence is a measure for determining how different one statistical distribution is from another statistical distribution. The inventor has realized that a **color histogram** can be treated as a statistical distribution and that the Kullback informational divergence can be applied for **comparing** the candidate **color histogram** with the query **color histogram**. Experiments have shown that **retrieval of images** on the basis of a similarity obtained from applying the Kullback informational divergence on the respective color histograms gives very good results. Furthermore, the calculation of the

Kullback informational
divergence requires less computational effort than the known techniques, which
is very important since a large number of candidate images may need to be
compared with the query image.

Brief Summary Text - BSTX (12):

A further embodiment of the **image retrieval** system according to the
invention **compares** two **color histograms** of respective regions of the candidate
image with two **color histograms** of corresponding regions of the query image,
the spatial information in the respective images being employed when
determining the similarity. This improves the accuracy of determining the
similarity between the candidate image and the query image and a better
discrimination among the images in the database can be achieved.

Detailed Description Text - DETX (2):

FIG. 1 schematically shows an **image retrieval** system according to the
invention. The system 100 includes a database 102 with a potentially large
collection 104 of images. A purpose of such a system is to **retrieve from the collection one or more images** that match the wishes of a user of the system.
Those wishes are specified via a query image 106, which the user can enter into
the system via entry means 108. The entry unit may allow the user to compose
the query image from a number of existing images or to create the query image
from scratch. The system compares the query image

with the candidate images in the database and determines for each candidate image how similar it is to the query image. The system ranks the candidate images according to the established similarity. The system 100 **compares** images on the basis of their **color histogram**. To this end, the system includes first histogram unit 110 to determine a query color histogram 112 from the query image 106. The process of determining a color histogram from an image is explained in FIG. 3 below. The system also includes second histogram unit 114 to determine a candidate color histogram 116 from a particular candidate image 118. The first histogram unit and the second histogram unit may be integrated into one histogram means, which can act on the query image for generating the query color histogram and on the particular candidate image for generating the candidate color histogram respectively. The system further includes determining unit 120 to determine a similarity 122 on the basis of the query color histogram 112 and the candidate color histogram 116. Based on the similarity, the system presents a ranking of the candidate image on a display 126. The user may select an **image from this ranking which is retrieved** from the database via retrieval means 124 for further processing. This further processing may include temporarily storing the image in a file 128 for further selection. This may be implemented as that the system **retrieves a number of candidate images** and stores these in the file 128, from where the user makes a final selection as to which image is desired.

In such a way of working, the system makes a first selection from the large collection in the database 102 and the user selects the image or images from the much smaller collection in file 128.

Detailed Description Text - DETX (24):

In the embodiments of the **image retrieval** system described above, a single color histogram is made from the whole image. Because of this, the spatial information from the image is lost and the comparison of two images reflects only global similarity. For example if a user enters a query **image with a sky at the top and sand at the bottom, the retrieved images** are expected to have a mix of blue and beige, but not necessarily a sky and sand. A desirable result for the **retrieved candidate images** would be images with blue at the top and beige at the bottom. In order to achieve this result, a further embodiment of the system according to the invention determines a **color histogram** for a number of respective regions of the query image and **compares** these determined histograms with histograms of corresponding regions of the candidate image. The query image may be divided into regions using pre-fixed boundaries, e.g. the division of the image into a number of rectangles. Furthermore, the regions may be indicated manually by the user taking into account important objects in the query image. In this way, the user forces that a histogram is made for a region comprising the object of interest. The choice of the region size is important since it governs the emphasis

that is given to local information. In one extreme, the whole image is considered as a single region so that only global information is used for the comparison. In the other extreme, the region size matches the individual pixels. In one of the further embodiments of the **retrieval system according to the invention, the images** are divided into 4.times.4 rectangular regions.

Detailed Description Text - DETX (50):

FIG. 5 shows an overview of the method according to the invention. In a first step 502, a query image is obtained containing the wishes of the user. This image may be composed from existing images or may be sketched by the user, possibly on the basis of an existing image. Then in a second step 504, a query color histogram of the query image is determined. This query **color histogram** will be used in **comparing** the query image with candidate images from a database. In a third step 506, a candidate color histogram of one of such candidate images is obtained. Preferably this candidate color histogram has been prepared in advance at the moment the candidate image had been stored in the database. Then obtaining the candidate color histogram now, comes down to simply retrieving the histogram. Alternatively, the candidate color histogram could be created at this instant, i.e. at the time when it is needed. When the candidate color histogram has been obtained, the similarity between the query image and the candidate image is determined in a determining step 508. If in a

comparison step 510 it is ascertained that the images are similar enough, the particular candidate **image is retrieved** from the database in retrieval step 512. The particular candidate image may be directly presented to the user or may be temporarily stored in a file for later inspection. Then in step 514 it is determined whether all candidates images in the database have been dealt with. If this is not the case, a candidate color histogram of a next candidate image is obtained in step 506 and the process is repeated for this next candidate image.